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Effects of Zectran Spraying on Forest Birds and Frogs in New Brunswick

A. Effects on birds — P.A. Pearce

B. Effects on frogs — A.M. Rick

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EFFECTS OF ZECTRAN SPRAYING ON FOREST BIRDS AND FROGS IN NEW BRUNSWICK

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B. Effects on frogs -- Anne Meachem Rick, Canadian Wildlife Service, Ottawa, Ontario.

For Interdepartmental Committee on Forest Spraying Operations
November 1969

Abstract

Two 3000-acre forest plots in south-central New Brunswick were aerially sprayed to control spruce budworm in early June, 1969. The two treatments were 4½ days apart, and each was at an emission rate of 1 oz Zectran in 0.15 U.S.G./acre. Songbird censuses, post-spray searching for casualties, nest histories, and the behaviour of captives, all suggested no serious effects on birds. Counts of frogs and survival rates of caged tadpoles also suggested no serious effects on these forms attributable to Zectran, but some tadpole mortality was attributed to the fuel oil used in the formulation.

This submission summarizes the findings of Canadian Wildlife Service observers in areas sprayed under simulated operational conditions with the carbamate insecticide Zectran. This spraying was part of the program of field experimentation with potential spruce budworm control insecticides conducted by the Chemical Control Research Institute (C.C.R.I.) of the Department of Fisheries and Forestry.

Location

Experimental area Zectran 1 (referred to below as Z1)--a rectangular block of about 3,000 acres situated a short distance to the east of the Acadia Forest Experiment Station, Sunbury Co., N.B., and bisected diagonally by Little River. Experimental area Zectran 2 (referred to below as Z2)--a forest tract of the same size and configuration located within the bounds of the Acadia Forest Experiment Station and bisected longitudinally by Burpee Mill Stream. Control areas: (a) for bird study--south of Muzroll Brook and about 7 miles southeast of Doaktown; (b) for frog study--just south of Z1 and west, south, and east of Z2.

Treatment

Z1 and Z2 were sprayed with fuel oil at 0.15 U.S.G./acre during the evening of June 1 by a team of 3 modified TBM aircraft to test emission rates and spray coverage. Both areas were sprayed with Zectran at a dosage of 1 oz in 0.15 U.S.G./acre formulation (Dowanol TPM solvent and fuel oil) during the late evening of June 4. This treatment was repeated early on June 9 for a total dosage of 2 oz active ingredient in 0.30 U.S.G./acre. The foliage was dry at the time of each spray application. Operational blocks about 3 miles to the north of the bird study control area were

sprayed on June 1 and 2 with Sumithion at a dosage 2 oz in 0.15 U.S.G. formulation/acre. The adjustment of operational block boundaries before the second application of Sumithion at this dosage resulted in the inclusion of the control transect in the southern part of a spray block. Sprayers were instructed to remain clear of the area. Ground observers in the vicinity at the time of spraying heard but did not see any spray aircraft. Though the control transect was not sprayed directly it is possible that it was subjected to some drift.

A. Effects on birds

Methods

1. Pre- and post-spray bird counts were made by a transect method, with area control in Z2 and without in Z1. In Z1 a 2 1/2 mile "census" route was marked along a road running through and down the centre of the block. An observer walked slowly along the route, noting by species the number of birds seen and heard and at the same time making a song count. In Z2 lines 1 mile long were marked through the forest parallel to and 5 chains on each side of a straight road bisecting the block in a direction approximately at right angles to the planned flight path of the spray aircraft. Two observers in radio contact with each other walked at the same rate slowly along the lines and noted by species the number of birds seen and heard between them. Upon completion of the count the total number of birds noted in the marked 80-acre "plot" was known. A similar 80-acre "plot" was marked in the control area where counts were made by both of the methods just described. (The single-observer method merely required a count along the

2 mile boundary). It was thus possible to use counts in the one area as a control against counts in both Z1 and Z2. Counts were made early in the morning, several before and after spraying. Each took about the same amount of time and was completed before the beginning of a decline in vocal activity.

2. About 10 man-hours on June 5 and 7 man-hours on June 9 were devoted to intensive searching of the spray zones for carcasses or any evidence of bird incapacitation. The behaviour of birds was critically observed during and after the post-spray counts.

3. Eight white-throated sparrows were trapped on June 3, placed in separate cages and supplied with food and water. They were taken to the field the next day. Four were placed on the ground in open spaces at four separate points in Z2. The others were placed in an open area 1 mile outside the spray block. Spray detection cards were positioned at all locations. An hour after spraying the cages of two of the experimental birds were filled with twigs and foliage from nearby coniferous and broadleaved trees. Two of the cages containing the control birds were treated in the same manner. The birds were taken to the field again on June 8 and the foliage removed from the cages. As spraying was postponed they were returned to the laboratory. Early the next morning the cages and fresh cards were positioned as on June 3. Two hours after the completion of spraying foliage was again put in the cages that had been so treated after the first spray application. All birds were taken to the laboratory and kept under periodic observation during the following 4 days.

4. Nests of a yellow-bellied sapsucker, a robin, and 4 white-throated sparrows were located in Z2. As time permitted, the history of these nests was followed up after spraying.

Results and Discussion

"Census" data are presented in Tables 1 to 4 and the population indices derived from them in Table 5. Counts in all 3 areas were made in comparable weather conditions and were not seriously affected by wind or rain, two weather variables that suppress bird song more than others. Experimental areas apparently supported denser and more diversified populations than the control. This may be partly attributed to: (a) the greater experience of observers in Z1 and Z2, (b) a slightly longer Z1 transect than control, (c) cutting that took place on the last 2 to 3 chains of the control transect during the monitoring period. In addition, floristic and budworm population density differences may have accounted for significantly smaller bird populations in the control area. Some of the variability in the "census" data may be accounted for by (a) arrival on the study areas of late migrants (vireos and particularly flycatchers such as the yellow-bellied, olive-sided, and wood pewee), and (b) greater mobility of some species and possible decline of activities associated with breeding (chickadees, purple finch). Control counts were more variable than the ones in sprayed areas and may be partly explained by the factors outlined above. In all areas the numbers of thrushes (more "reliable" as evening singers) varied a great deal. A drop-off in the numbers of some species (e.g. black-throated green warbler) after spraying was matched by a decrease in the control area. No major decline in the numbers of any

Table 1. Bird count results, Experimental Area Zectran 1

Species*	Number of birds recorded						
	June 1	June 2	June 3	June 6	June 9+	June 11	June 14
Yellow-shafted flicker	0	4	3	3	1	2	1
Yellow-bellied sapsucker	17	18	17	20	14	16	14
Yellow-bellied flycatcher	4	6	2	4	10	10	10
Least flycatcher	14	9	15	9	8	12	12
Eastern wood pewee	0	0	2	3	3	6	5
Olive-sided flycatcher	1	3	1	5	3	5	4
Gray jay	2	1	1	6	3	2	3
Blue jay	8	6	1	4	3	4	4
Common raven	2	7	2	5	0	3	2
Black-capped chickadee	1	2	1	1	2	0	2
Boreal chickadee	3	2	4	4	6	3	4
Red-breasted nuthatch	6	4	4	5	4	3	3
Winter wren	10	5	9	7	6	5	2
Robin	8	11	9	13	9	16	5
Hermit thrush	3	6	3	11	11	6	9
Swainson's thrush	18	14	15	11	17	28	28
Veery	1	0	2	1	2	2	2
Golden-crowned kinglet	4	2	3	2	0	2	3
Ruby-crowned kinglet	14	17	17	18	18	18	14
Vireo spp.	4	4	6	6	8	9	7
Black-and-white warbler	6	6	10	11	10	10	8
Tennessee warbler	52	58	61	49	59	59	63
Nashville warbler	5	3	5	4	5	5	5
Parula warbler	4	5	7	5	8	8	5
Magnolia warbler	24	27	32	31	34	34	27
Cape May warbler	16	18	11	9	12	17	17
Myrtle warbler	8	7	9	4	6	6	7
Black-throated green warbler	12	13	11	15	6	9	9
Blackburnian warbler	4	4	3	3	2	4	5
Chestnut-sided warbler	0	0	1	1	1	1	3
Bay-breasted warbler	23	28	26	19	22	16	21
Ovenbird	27	24	29	29	27	29	35
Northern waterthrush	3	3	3	3	2	2	3
Yellowthroat	24	28	28	21	20	17	25
Wilson's warbler	2	4	2	1	0	3	0
Canada warbler	2	6	6	12	9	6	17
American redstart	11	11	11	15	13	12	12
Brown-headed cowbird	8	5	8	3	5	4	5
Purple finch	24	23	28	13	14	10	7
Slate-colored junco	18	10	8	13	5	6	7
Chipping sparrow	2	3	1	1	1	2	0
White-throated sparrow	37	53	51	52	40	49	48
Lincoln's sparrow	2	2	2	1	0	0	0

First spray application - evening of June 4

Second spray application - morning of June 9

* Only those recorded consistently, after initial arrival on study area, at least up to the time of first spray application.

\+ Count made while area being sprayed.

Table 2. Bird count results, Control Area

Species*	Number of birds recorded							
	June 1	June 2	June 3		June 6	June 9	June 11	June 14
Yellow-bellied sapsucker	7	13	11		6	13	11	8
Least flycatcher	15	9	12		10	8	9	15
Eastern wood pewee	0	1	0		3	5	7	7
Olive-sided flycatcher	0	3	0		3	2	4	3
Black-capped chickadee	4	4	1		4	1	1	0
Red-breasted nuthatch	5	6	2		2	5	2	1
Brown creeper	4	7	5		3	2	0	0
Winter wren	7	9	9		5	6	4	7
Hylocichla spp.	12	7	9		12	8	11	15
Ruby-crowned kinglet	6	2	4		3	2	2	0
Vireo spp.	1	3	2		4	4	4	3
Tennessee warbler	22	14	24		17	18	24	33
Parula warbler	3	3	5		5	4	3	7
Magnolia warbler	10	4	14		9	8	9	7
Cape May warbler	0	1	3		2	3	1	5
Black-throated blue warbler	2	2	2		2	2	2	3
Myrtle warbler	5	3	2		3	2	1	1
Black-throated green warbler	5	6	8		1	1	4	3
Blackburnian warbler	5	4	8		6	3	5	7
Bay-breasted warbler	13	10	13		8	7	6	3
Ovenbird	7	11	13		15	13	15	14
Yellowthroat	7	2	2		2	1	3	0
Canada warbler	2	3	4		5	3	1	8
American redstart	8	2	8		10	6	6	9
Rose-breasted grosbeak	2	1	4		7	8	6	1
Slate-colored junco	3	4	3		4	1	1	3
White-throated sparrow	29	34	24		24	26	24	17

Experimental Area Zectran 1 sprayed on evening of June 4

Experimental Area Zectran 1 sprayed on morning of June 9

* Only those recorded consistently, after initial arrival on control area, at least up to the time of first spray application on Experimental Area Zectran 1.

Table 3. Bird count results, Experimental Area Zectran 2

Species*	Number of birds recorded									
	May 28	May 29	May 30	May 31	June 4	June 5	June 8		June 10	June 13
Yellow-bellied sapsucker	4	3	4	5	2	3	3		2	1
Yellow-bellied flycatcher	0	0	1	2	2	5	9		10	11
Least flycatcher	29	30	31	25	27	24	26		26	23
Eastern wood pewee	0	0	0	1	1	4	1		2	4
Black-capped chickadee	1	3	5	1	1	0	2		4	0
Boreal chickadee	8	4	3	5	4	6	5		7	2
Red-breasted nuthatch	2	4	5	3	0	2	3		1	2
Hermit thrush	4	2	4	3	6	1	3		1	8
Swainson's thrush	17	22	28	20	19	21	20		22	18
Golden-crowned kinglet	3	4	10	4	3	6	3		1	2
Ruby-crowned kinglet	8	9	11	11	6	6	7		4	6
Vireo spp.	2	0	2	2	5	8	9		5	5
Black-and-white warbler	2	4	5	6	4	4	1		2	2
Tennessee warbler	21	30	39	33	32	32	40		23	23
Nashville warbler	0	4	5	4	6	7	5		2	3
Parula warbler	7	2	9	3	4	4	2		3	4
Magnolia warbler	17	18	18	21	31	21	18		9	14
Cape May warbler	15	18	20	15	9	8	11		11	11
Myrtle warbler	7	8	10	9	9	6	4		6	5
Black-throated green warbler	15	14	10	11	13	8	9		11	9
Blackburnian warbler	3	5	10	4	8	1	3		7	8
Bay-breasted warbler	28	33	35	39	44	31	33		40	31
Ovenbird	13	25	21	18	28	16	17		26	23
Yellowthroat	7	9	11	10	16	20	11		10	9
Wilson's warbler	0	0	1	3	2	1	1		1	0
Canada warbler	0	1	2	1	5	3	1		1	1
American redstart	6	16	17	23	24	21	18		15	18
Brown-headed cowbird	5	1	2	2	4	4	1		3	2
Purple finch	17	14	14	9	21	17	11		9	6
Slate-colored junco	12	5	5	4	5	10	8		4	6
White-throated sparrow	26	21	18	23	16	24	21		19	15

First spray application - evening of June 4

Second spray application - morning of June 9

* Only those recorded consistently, after initial arrival on study area, at least up to the time of first spray application.

Table 4. Bird count results, Control Area

Species*	Number of birds recorded									
	May 28	May 29	May 30	May 31	June 4	June 5	June 8		June 10	June 13
Yellow-bellied sapsucker	3	9	13	6	8	9	6		4	5
Least flycatcher	0	2	9	6	11	9	3		3	2
Eastern wood pewee	0	0	0	0	2	0	2		2	3
Olive-sided flycatcher	0	0	0	0	0	0	2		2	2
Red-breasted nuthatch	4	6	6	1	2	1	2		1	0
Winter wren	3	2	3	1	2	2	3		1	2
Hylocichla spp.	7	4	11	13	8	10	3		6	10
Golden-crowned kinglet	0	1	4	4	3	0	6		2	1
Ruby-crowned kinglet	0	1	2	2	2	2	3		2	1
Vireo spp.	0	1	1	1	2	1	2		4	1
Tennessee warbler	3	8	13	20	20	12	10		14	20
Parula warbler	2	4	5	4	4	1	4		1	2
Magnolia warbler	5	9	8	11	9	11	5		7	14
Cape May warbler	4	4	5	7	6	7	3		2	7
Black-throated blue warbler	0	2	2	1	2	5	3		1	2
Myrtle warbler	3	6	10	4	1	2	3		1	4
Black-throated green warbler	4	5	5	6	2	1	2		2	1
Blackburnian warbler	0	2	4	3	3	6	4		2	3
Bay-breasted warbler	2	1	11	9	13	15	11		6	11
Ovenbird	3	8	6	4	5	5	6		6	7
Yellowthroat	8	10	7	9	6	2	5		3	9
Canada warbler	0	2	7	9	5	2	7		4	2
American redstart	2	7	6	6	4	2	5		5	2
Brown-headed cowbird	3	5	7	2	4	5	2		7	0
Purple finch	9	8	11	5	5	5	7		3	0
Slate-colored junco	10	8	8	2	5	4	2		9	4
White-throated sparrow	23	27	35	20	19	15	24		11	20

Experimental Area Zectran 2 sprayed on evening of June 4

Experimental Area Zectran 2 sprayed on morning of June 9

* Only those recorded consistently, after initial arrival on control area, at least up to the time of first spray application on Experimental Area Zectran 2.

Table 5. Population indices

Experimental area Zectran 1*

	June						
	1	2	3	6	9	11	14
Birds/minute	3.5	3.8	3.7	3.8	3.7	3.3	3.8
Songs/minute	14	14	16	16	16	15	18
Total species	51	55	57	56	48	58	56
Control							
Birds/minute	2.1	1.6	1.8	1.9	1.6	1.6	1.7
Songs/minute	10	7	10	10	9	12	12
Total species	34	35	36	39	39	38	34

Experimental area Zectran 2*

	May				June				
	28	29	30	31	4	5	8	10	13
Birds/minute	1.7	1.8	2.1	1.9	2.2	2.0	2.0	2.0	1.8
Total species	37	43	43	43	47	43	46	46	38
Control									
Birds/minute	0.8	1.0	1.4	1.3	1.2	1.2	1.1	1.0	1.1
Total species	29	34	36	34	34	37	38	38	32

* Sprayed evening of June 4 and morning of June 9.

species was noted. Probably most of the variability can be attributed to day-to-day fluctuations of bird activity and not to spraying effects.

No carcasses were found during intensive post-spray searching of Z1 and Z2. (Some of the difficulties of finding dead birds in the forest were reported previously to this committee). No birds were seen to behave in a manner thought to be abnormal. C.C.R.I. experimental plot #8, north of Hardwood Ridge, Sunbury Co., was sprayed with an ultra-low-volume formulation of Zectran in a graduated dosage averaging 1 oz/acre on the evening of June 17 and again on the morning of June 21. Six man-hours of post-spray searching in the plot failed to reveal any evidence of bird intoxication.

Detection cards placed near the captive birds used as a control showed no spray deposit. Those placed near the cages in the spray zone received a thorough deposit of fine spray droplets. All 8 birds remained active and apparently healthy throughout the 10 days during which they were held captive. Constant contact with contaminated foliage appeared to have no harmful effect, nor did the stress imposed by 3 journeys to the field and 2 visitations from a housecat. Upon release on June 13, all birds flew strongly to the nearest cover.

Shortage of time allowed the finding of only 6 nests in Z2 prior to spraying. The robin continued to incubate 3 eggs and when the nest was last visited on June 30 it contained 2 fledglings. The sapsucker was in the nest cavity at each visit to the site. On June 30 the cries of young were heard and a parent bird was seen carrying food to the nest. Two of the white-throated sparrow nests suffered predation. Four young were believed

to have been raised successfully in the third white-throat nest. At the fourth nest the female was incubating 4 eggs on June 5 and June 9. On June 18 the nest contained 2 nestlings and 2 unhatched eggs. On June 30 the 2 unhatched eggs remained, the 2 young having left or been taken from the nest.

Conclusions

"Census" data, post-spray searching, nest history and the behaviour of captive birds all failed to indicate that birds were adversely affected by the spray. Conclusions are that, early in the breeding season, no serious hazard to forest birds is presented by aerial spraying of Zectran in the late evening and in the early morning at a time interval of 4 1/2 days and at a total theoretical emission dosage of 2 oz active ingredient in 0.30 U.S.G. formulation/acre. The monitoring techniques employed and the very limited manpower input precluded the detection of any subtle effects on breeding behaviour or any assessment of the significance of reduced food availability.

B. Effects on frogs and tadpoles

A limited monitoring study was undertaken to assess the immediate hazard to frogs and tadpoles of Zectran spraying. Frogs represent an important component of the forest fauna; they feed on insects and other small invertebrates, and are themselves eaten by many vertebrates. While frogs are carnivorous air-breathers, their larvae, the tadpoles, are herbivorous water-breathers. Thus, this study considers both fully aquatic and amphibious life forms.

Methods

A survey of the two Zectran plots and the nearby areas was made on May 31 and June 1 to locate frog ponds and to determine what frogs occurred in the area. Six species were found: Hyla crucifer, Bufo americanus, Rana clamitans, R. sylvatica, R. pipiens, and R. septentrionalis. The green frog, Rana clamitans, was the most abundant of the six species at ponds and was most readily observable.

Data were obtained from 10 ponds. Of these, 4 were controls (Numbers 2, 5, 9, 11), five were experimental ponds on the Z1 plot (Numbers 6, 7, 8, 12, 13), and one an experimental pond (Number 10) on the Z2 plot. Tadpoles but not frogs were counted at Pond 11. All control ponds were within 1½ miles of either Z1 and Z2.

An index to frog species populations at each pond was made by repeatedly counting all visible individuals. Frogs were counted by walking around and/or through each pond and recording numbers of each species seen. At night the counts were made with the aid of headlamps.

Individual frogs were not handled. This technique allowed rapid counting with a minimum of disturbance and risk of injury to the frogs.

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Counts were made twice each day (afternoon and night) whenever possible, from May 31 through June 11, omitting June 7, and June 18. Ponds were usually visited in the same order each day, so that counts of the same pond on succeeding days would be made at approximately the same hour each day.

No attempt was made to count individual spring peepers, Hyla crucifer. These small, inconspicuous frogs could be heard calling during the evening at ponds and in the nearby woods. Rough estimates of their activity were made by judging chorus intensity.

Records were kept of all dead frogs found in the control and experimental ponds during the regular census counts.

Mortality of tadpoles was measured by holding them in cages made of aluminum screening cut and folded to form containers approximately 18" x 4½" x 3". Each cage was filled with 20 small tadpoles or several large ones, then submerged in the pond from which the tadpoles had been taken. These cages effectively contained the tadpoles while allowing their microscopic food to enter. Tadpoles were caged within one hour after the fuel oil spray on June 1, but up to several hours before the Zectran sprays on June 4 and June 9. Caged tadpoles were checked once each day and any mortality recorded. Tadpoles remained in cages from 2 to 6 days; at most ponds fresh tadpoles were introduced into the cages before each Zectran spray.

Spray cards were set out at all ponds before each spray.

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Results and Discussion

A total of 1741 individual frog observations was made during the study period: green frog, Rana clamitans - 1679; American toad, Bufo americanus - 57; leopard frog, Rana pipiens - 4; wood frog, Rana sylvatica - 1. Only the observations for the green frog were numerous enough to be useful in evaluating spraying effects on frogs; they are discussed in detail below.

The green frog counts include a few mink frogs, Rana septentrionalis, a species which closely resembles some green frogs and could not be distinguished from them using our counting techniques. However, mink frogs seemed to be rare in the study area, and their inclusion in the green frog counts should not affect the conclusions made about green frogs. Table I lists daily counts of green frogs throughout the study.

Many variables such as rainfall, air and water temperature, time of day, breeding activity, etc., can affect the numbers of green frogs visible at ponds during any one counting period. For example, an evening shower on June 3 provided enough moisture to allow frogs to leave the immediate area of the ponds; counts made after 10 pm on this date at ponds 2, 6, 7, 8, and 9 are low and reflect temporary frog dispersal rather than mortality.

The data in Table I show that green frog counts in both control and experimental ponds followed similar patterns. Frog numbers at ponds either remained relatively stable or increased slightly, depending on age composition and numbers of frogs, and the resultant degree of breeding activity. No changes in numbers were observed that could be attributed to spraying with either oil or Zectran in oil. Spray cards confirmed that spray coverage of experimental ponds was good and that controls did not receive spray.

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Table I. Numbers of green frogs, Rana clamitans, at experimental and control ponds during each counting period.

	Pond No.	Time	May 31	June 1 eve. oil	1	2	3	June 4 eve. Zectran	4	5	6	7	June 8	June 9 morn. Zectran	9	10	11	18
Control Ponds	2	A	6		13	12	-		17	19	22	-	18		24	20	14	9
		N	-		-	15	(2)[d]		16	24	12	-	-		21	27	21	11
	5	A	2		4	3	-		3	6	8	-	7		6	5	5	3
		N	-		2	-	-		2	8	2	-	-		5	8	6	1
	9	A	6		-	13	-		23	34	35	-	31		38	32	35	33
		N	-		20	24	19(9)		30	32	23	-	-		38	33	45	25
Experimental Ponds	3	A	10		8	8	-		-	-	-	-	-		-	-	-	
		N	-		14	9[a]	-		-	-	-	-	-		-	-	-	
	6	A	4		-	8	-		7	9	11	-	5		2	4	7	3
		N	-		8	13	11(0)		6	7	4	-	-		9	6	8	4
	7	A	2		-	1	-		2	4	2	-	3		2	2	3	4
		N	-		4	2	3(1)		3	4	2	-	-		4	3	2	6
	8	A	4		-	1	-		6	9	10	-	14		17	12	11	9
		N	-		5	6	5(0)		11	7	7	-	-		11	12	11	14
	10	A	-		-	-	-		8	14	16	-	16		12	6	10	10
		N	-		2	0[b]	0		9	13	7	-	-		7	17	17	8
	12	A	-		-	-	-[c]		3	9	9	-	5		1	3	5	2
		N	-		-	-	-		4	4	1	-	-		2	3	1	3
	13	A	-		-	-	-[c]		5	3	2	-	4		3	1	2	2
		N	-		-	-	-		4	1	-	-	-		2	5	2	4

A - afternoon
N - night
a - pond destroyed by road grader on June 3
b - pond partially filled in by road grading equipment on June 3; shape of pond drastically altered
c - no counts made prior to June 4
d - counts in parentheses made after 10 pm on June 3

During the study four frogs were found dead at control ponds, but none at experimental ponds. A dead spring peeper was found at Pond 5 on the afternoon of June 5, and three dead green frogs were seen at Pond 9 on the afternoon of June 18.

Nightly choruses of spring peepers at the study ponds and in nearby woods showed no obvious alterations in intensity which could be correlated with any of the three sprayings.

Most of the tadpoles used in the cage tests were wood frog tadpoles (common at this time of year), although some individuals of other species were included. Tadpole cages were set in Control Ponds 5, 9, and 11, and in Experimental Ponds 6, 7, 8, 12, and 13. In many of the cages no tadpole mortality was observed; slight mortality seen in some control and experimental pond cages was judged due to natural causes. Only in Experimental Pond 6 was significant mortality noted. This pond consisted of a small, shallow ditch on the north side of the road, connected by a culvert to a pond at the south side of the road. Of 20 tadpoles placed in a cage in the north ditch just after the oil spray on June 1, 6 were dead on the afternoon of June 2, and a seventh by June 3. Two additional cages of 20 were placed in the south pond on June 2 and three in the north ditch on June 2; there were no deaths in these cages to the end of the observation period on June 4. Of four cages (two in the north ditch, two in the south pond) placed on June 4 before the Zectran in oil spray, mortality on June 5 was 13/20 and 1/20 on the north and 0/20 and 5/20 on the south. No further deaths were seen among these tadpoles the next day, after which the cages were emptied. No dead tadpoles were found in four cages of 20 observed through the second Zectran in oil spray on June 9.

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Deaths of caged tadpoles at Pond 6 after both the oil spray and the first Zectran in oil spray were probably caused by the oil film in shallow water near the culvert rather than by Zectran. Mortality occurred almost entirely during the day following spraying and did not continue on subsequent days. We do not know why there was no tadpole mortality at this pond after the June 9 spray.

Conclusions

Forest spraying with fuel oil or Zectran in fuel oil as described in the introduction did not adversely affect populations of green frogs observed from May 31 to June 18 at ponds in the sprayed area. During the entire study period only four dead frogs, three green frogs and one spring peeper, were found; these individuals were all found in control ponds. Nightly choruses of spring peepers in the sprayed area did not seem to be affected by spraying. The only observed undesirable effect of spraying was mortality among tadpoles occurring within one day after the oil spray and the first Zectran in oil spray. This mortality can be attributed to the effects of fuel oil rather than Zectran. While only green frogs were present in sufficient numbers to allow reliable pre- and post-spray comparisons, there was no obvious effect of spraying in the other toad and frog species. It is concluded that future spray programs carried out under similar conditions should pose no serious hazard to either frogs or tadpoles.

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